

Polarized Lines in Supernovae: Observations and Modeling

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University of Denver

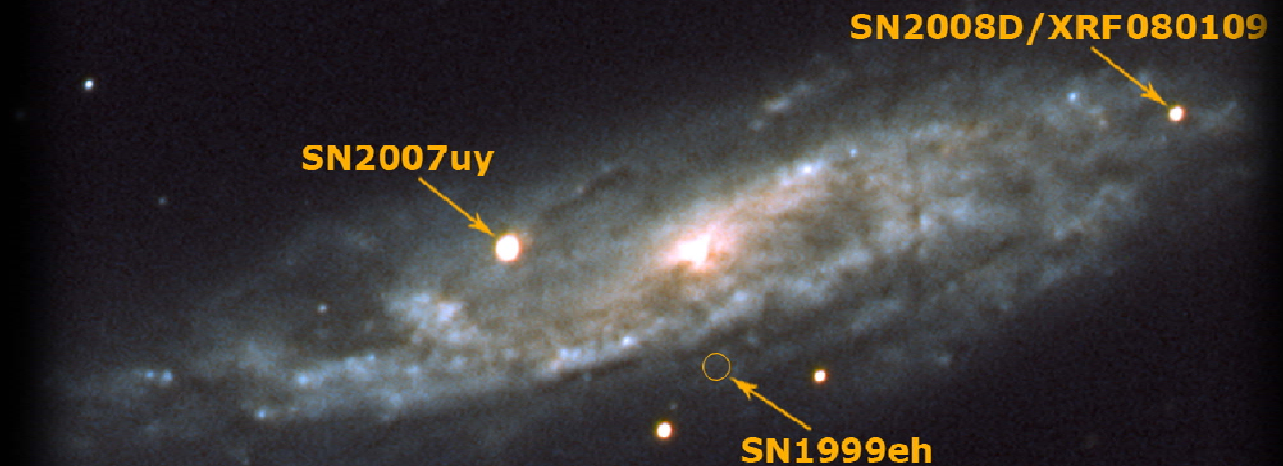
A. Filippenko (UCB)
P. Nugent (LBL)
NSF AAPF

SN 1994D



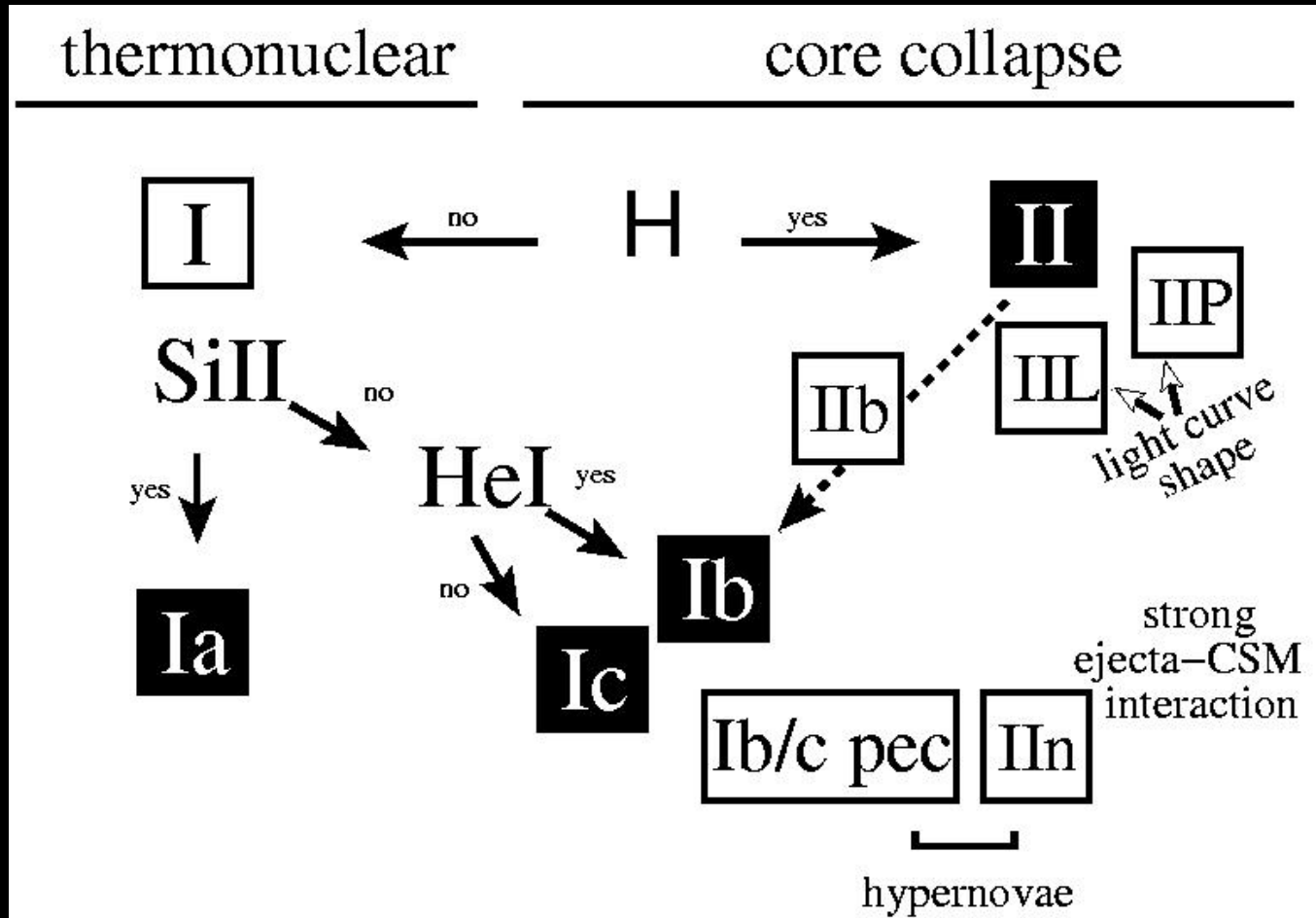
Outline

- Overview of SN polarization
- Recent observational results
- Modeling efforts
- Future prospects
- Related announcements



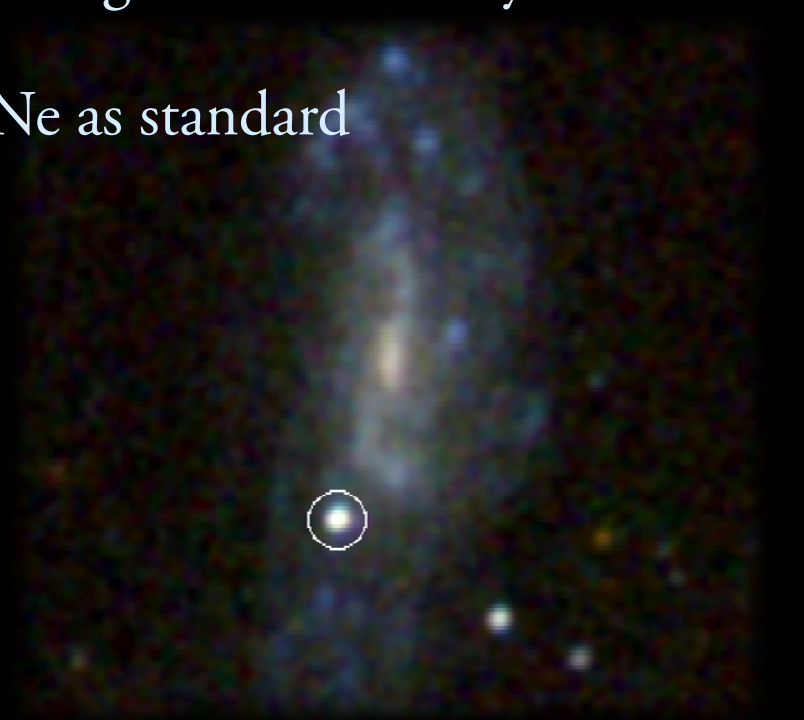
NGC 2770

All types of supernovae can be polarized!



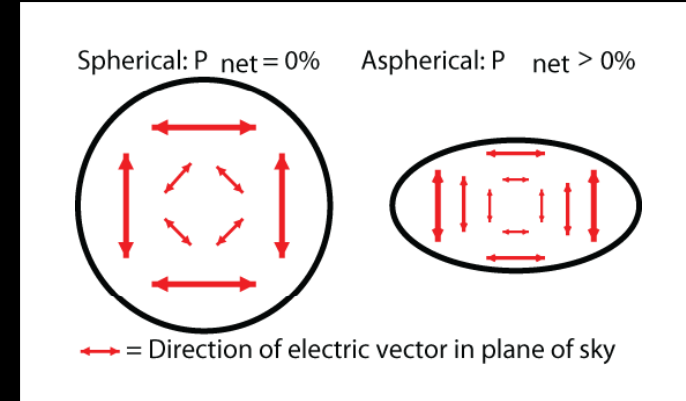
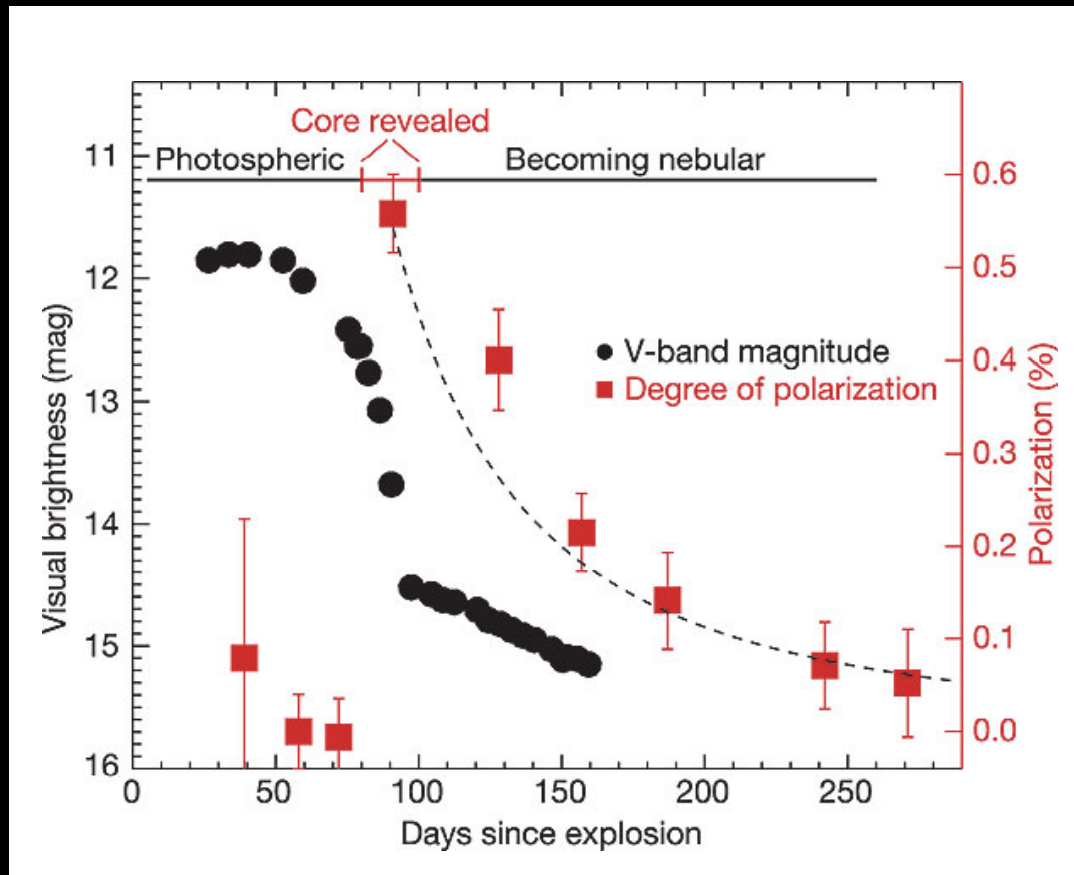
Why do we care about SN polarization?

- It yields insight into SN collapse/explosion mechanisms.
- It tells us about SN progenitors (stellar winds, CSM).
- It helps us probe stellar evolution at large distances/early times.
- It has implications for the use of SNe as standard candles/yardsticks.



SN 2008aq

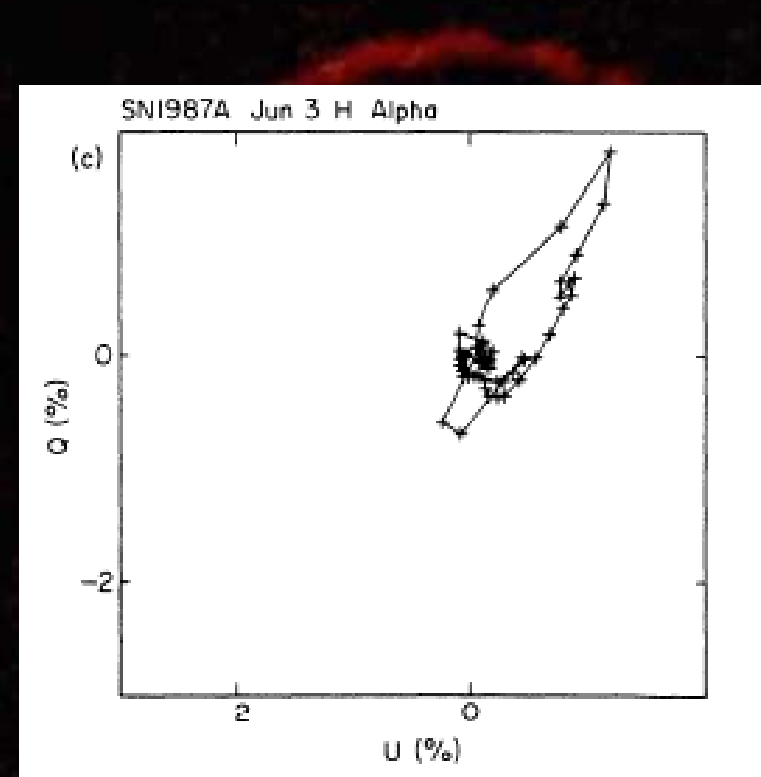
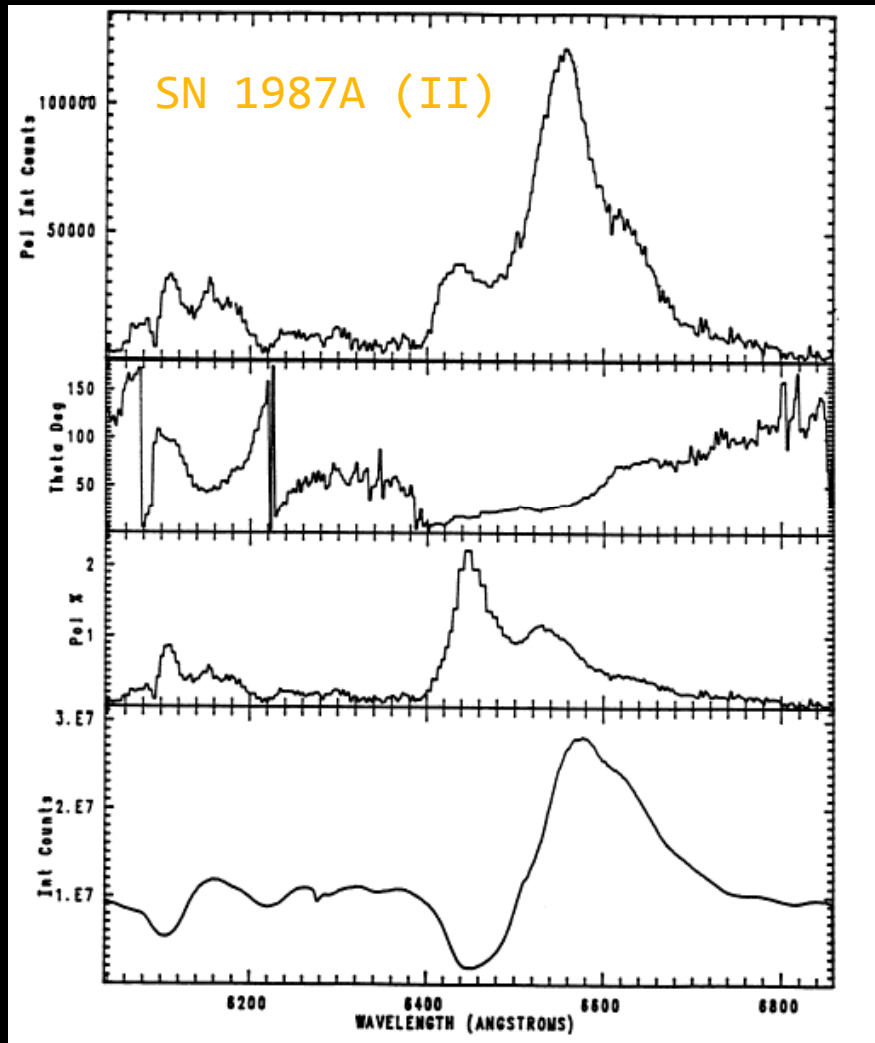
Broadband polarization measurements of supernovae indicate ejecta asphericity.



Leonard et al. 2000

Leonard et al. 2006

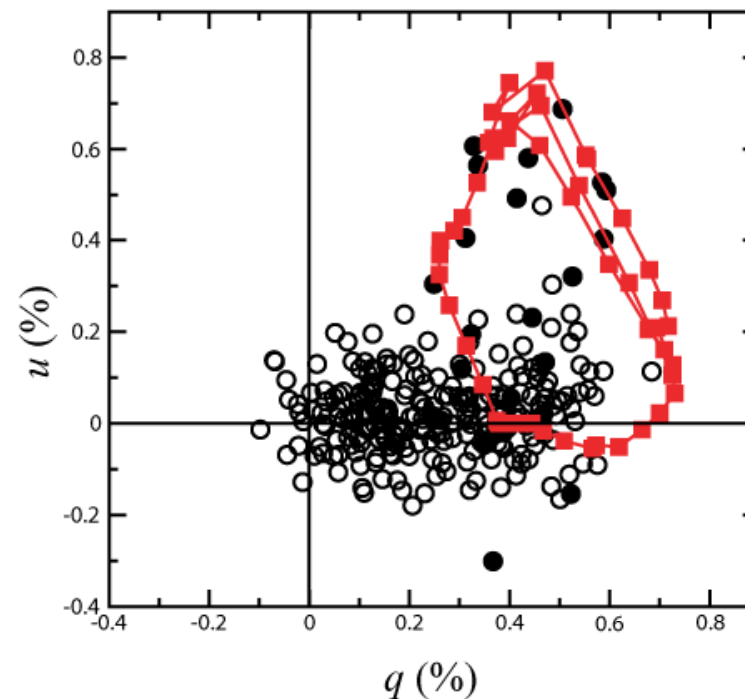
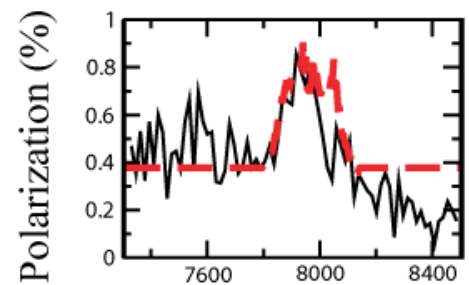
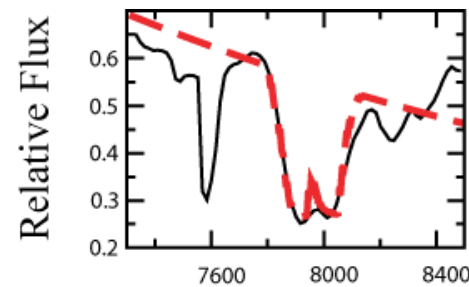
As of Pol '04, spectropolarimetry was becoming more common.



Cropper et al. 1988

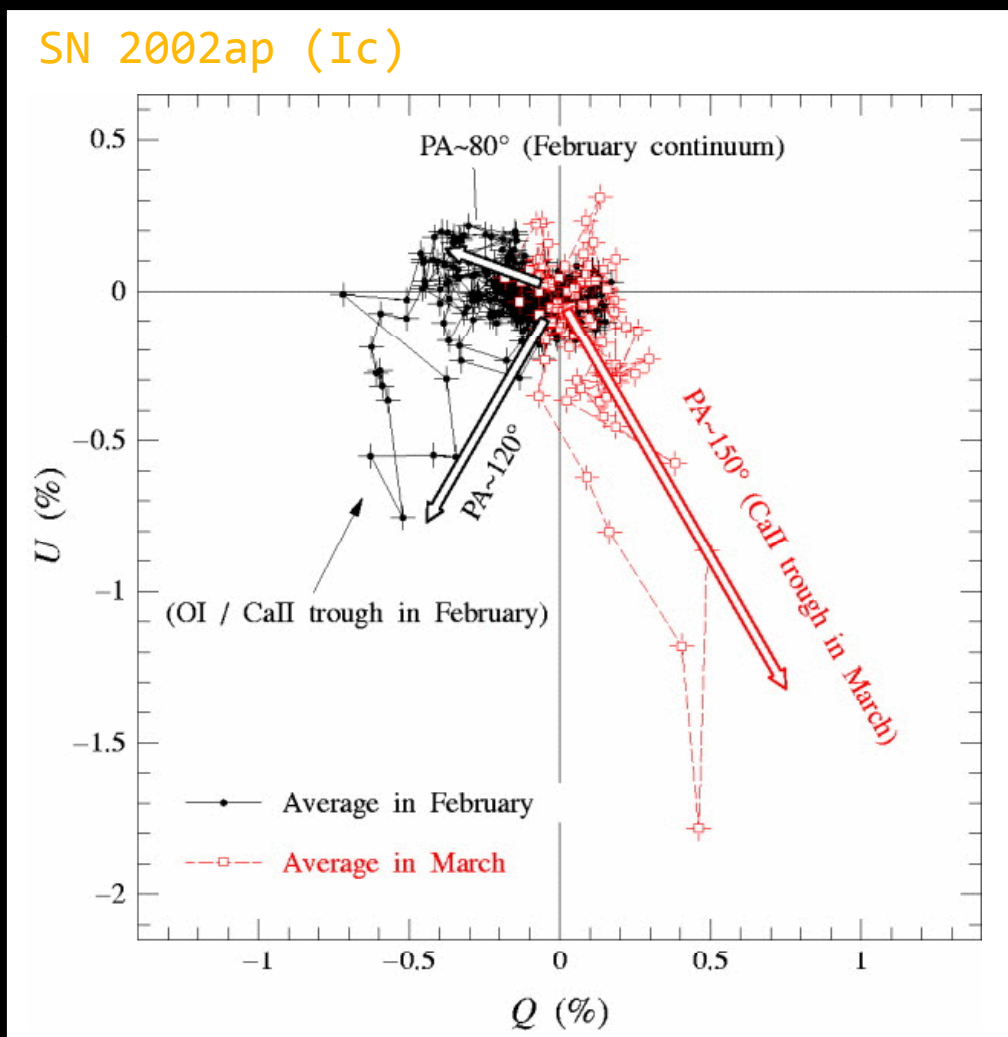
As of Pol '04, spectropolarimetry was becoming more common.

SN 2001el (Ia)



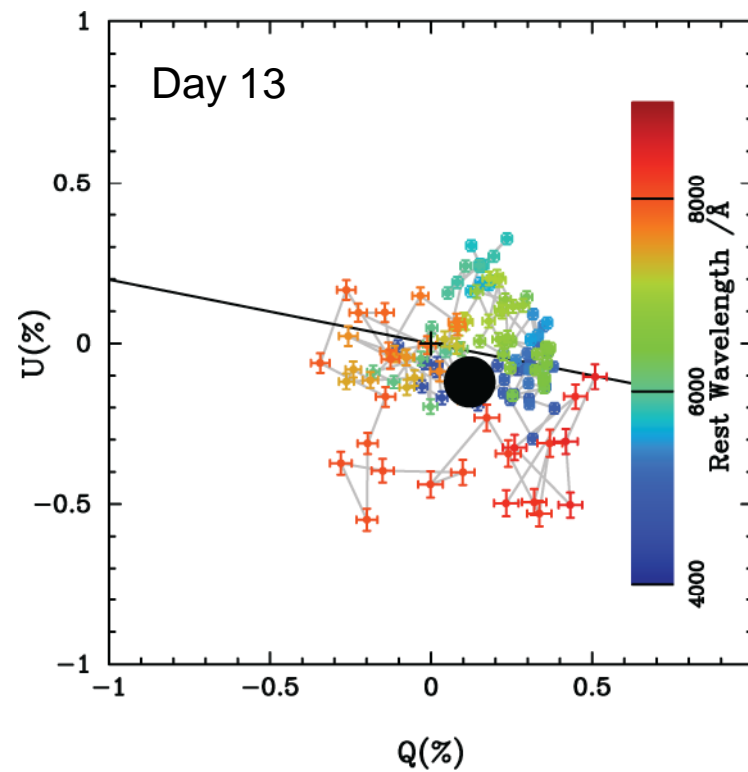
— SN2001el ○ continuum ● HVC CaII lines — clumped shell model

As of Pol '04, spectropolarimetry was becoming more common.



More supernovae are showing variations with time...

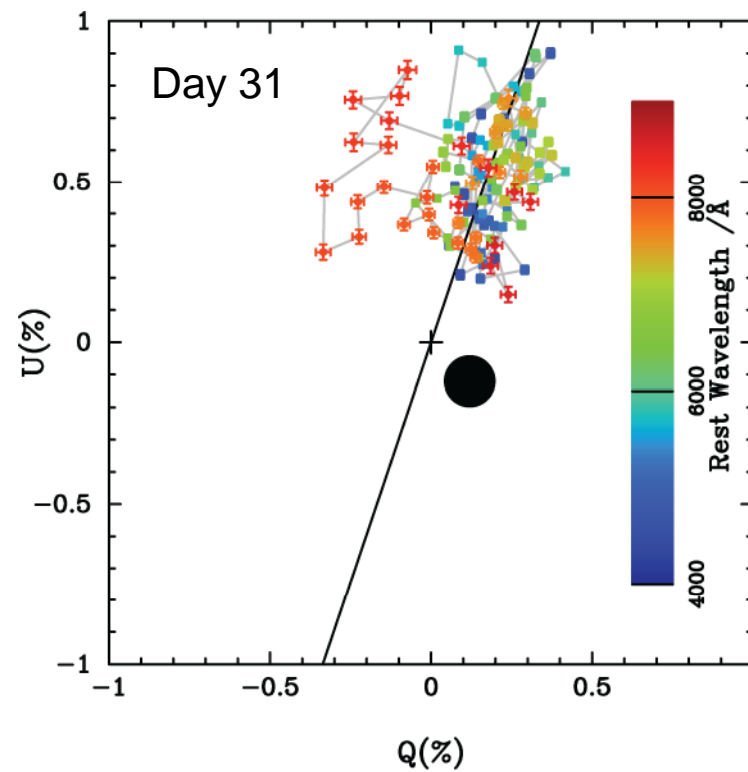
SN 2001ig (IIb)



Maud et al. 2007

More supernovae are showing variations with time...

SN 2001ig (IIb)



Maud et al. 2007

...and signatures of multiple symmetry axes.

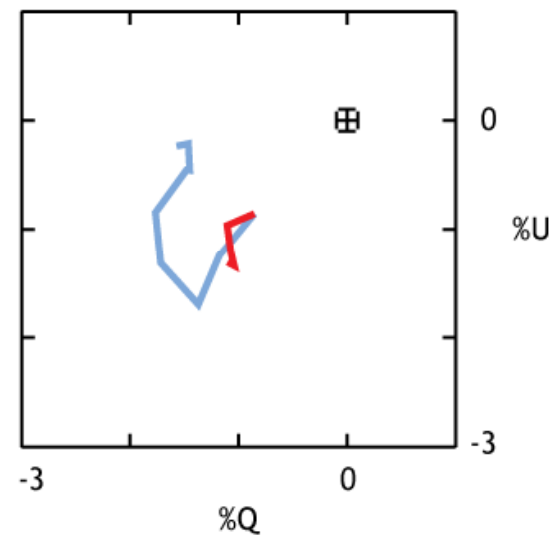
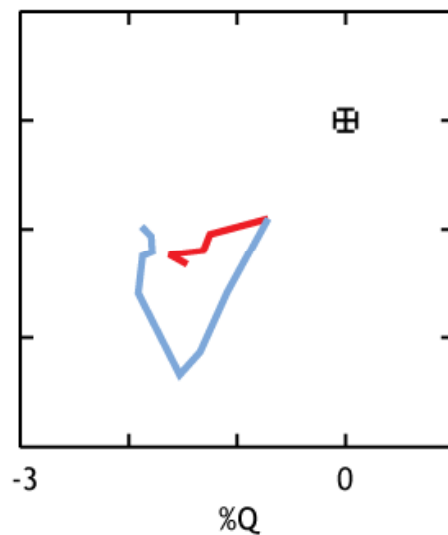
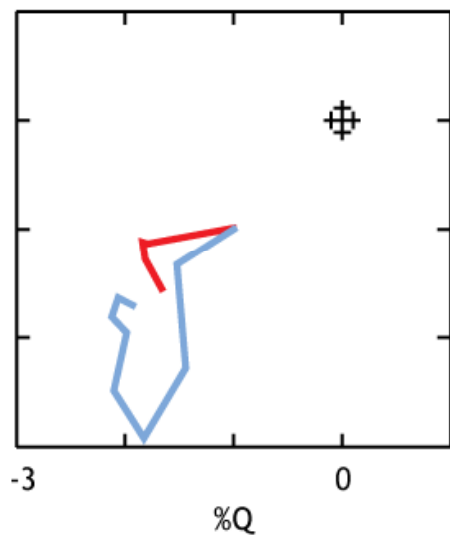
SN 1997eg (IIn)

Day 16

Day 44

Day 93

H α
50Å bins



...and signatures of multiple symmetry axes.

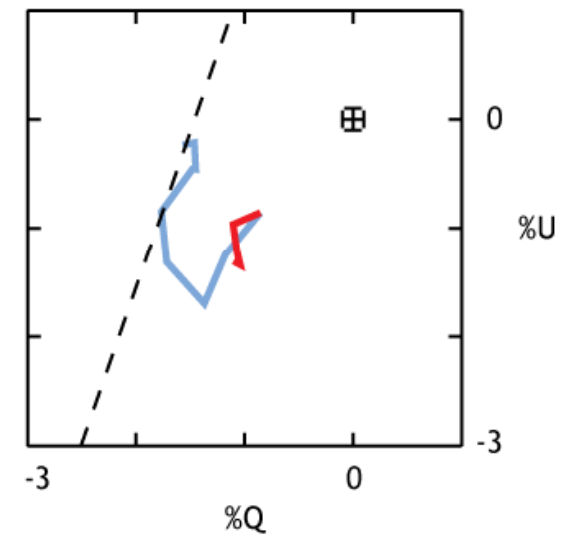
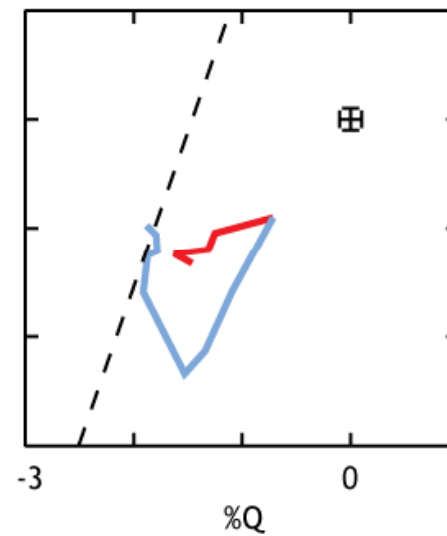
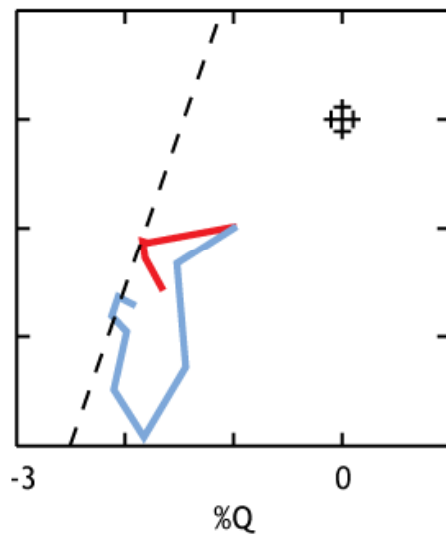
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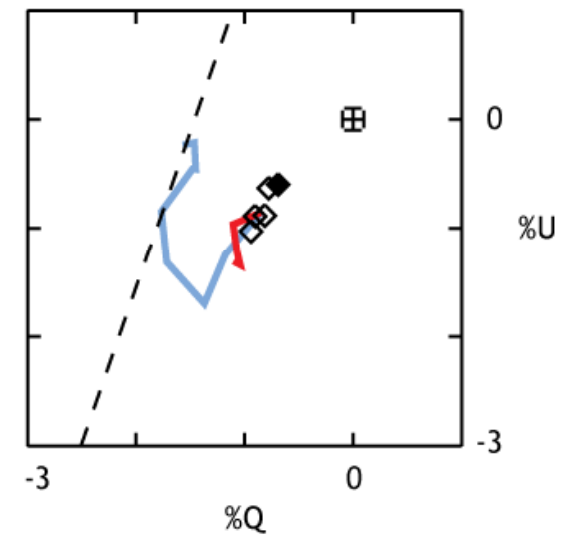
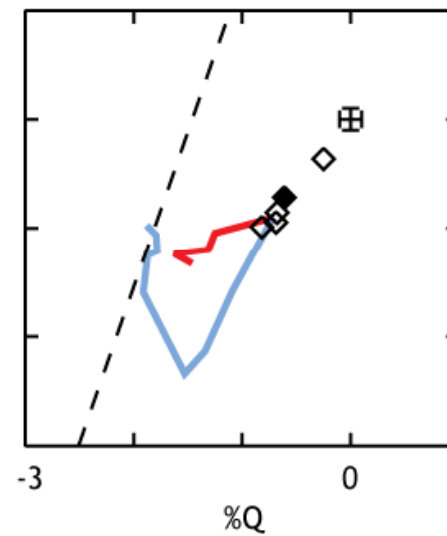
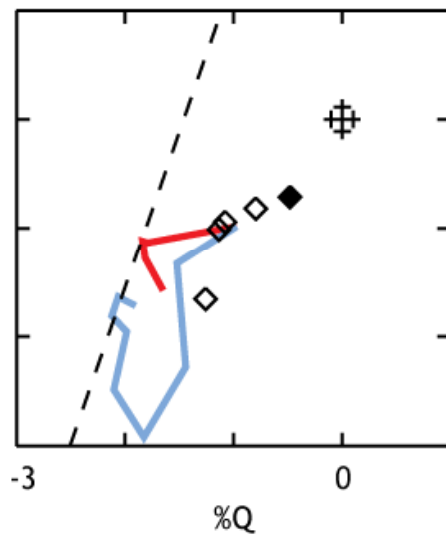
SN 1997eg (IIn)

Day 16

Day 44

Day 93

H α
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...and signatures of multiple symmetry axes.
(\rightarrow not due only to binarity!)

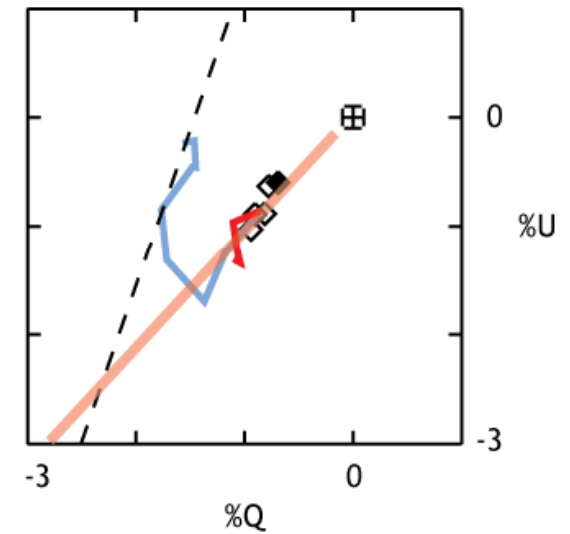
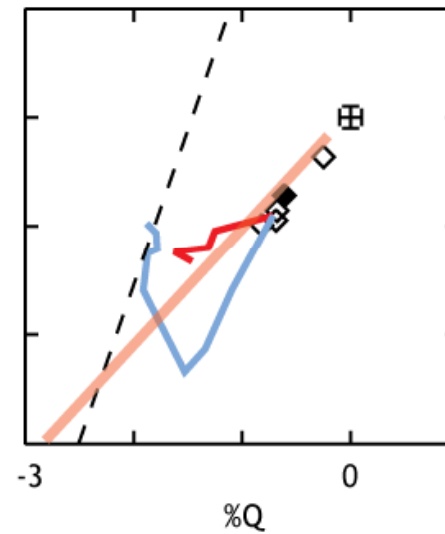
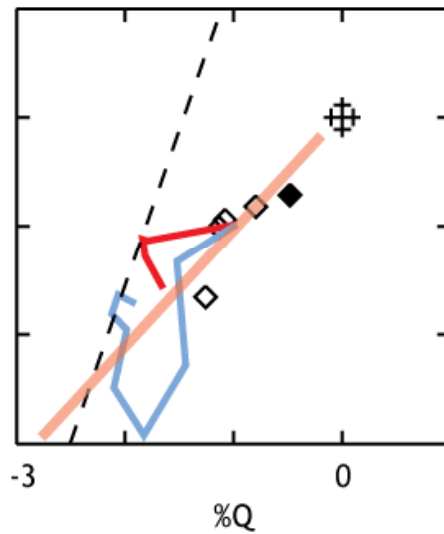
SN 1997eg (IIn)

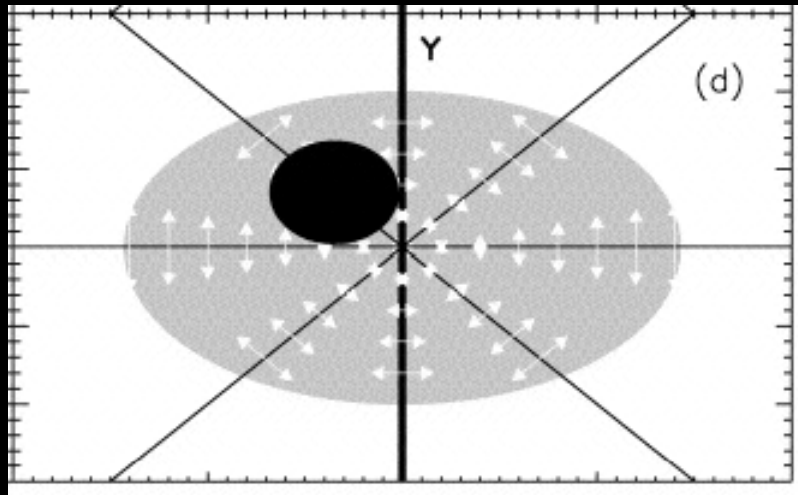
Day 16

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H α
50Å bins

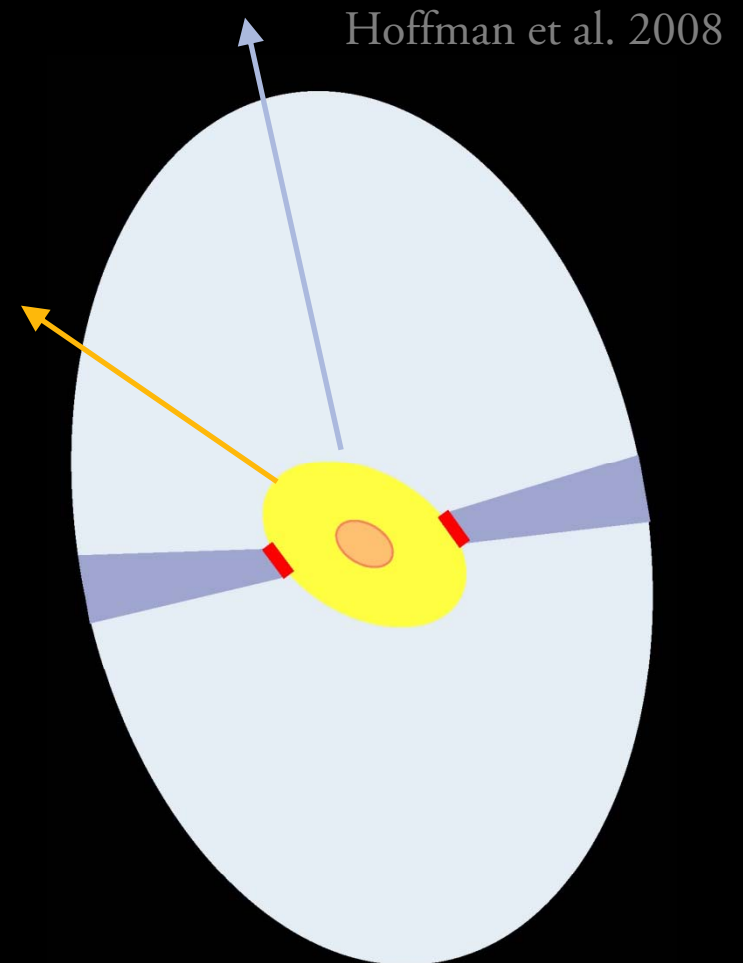


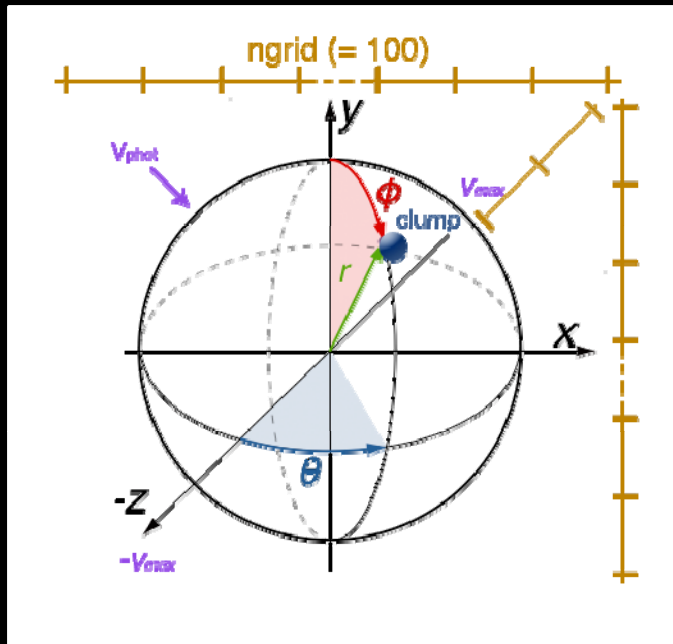


Kasen et al. 2003

Line polarization may occur via

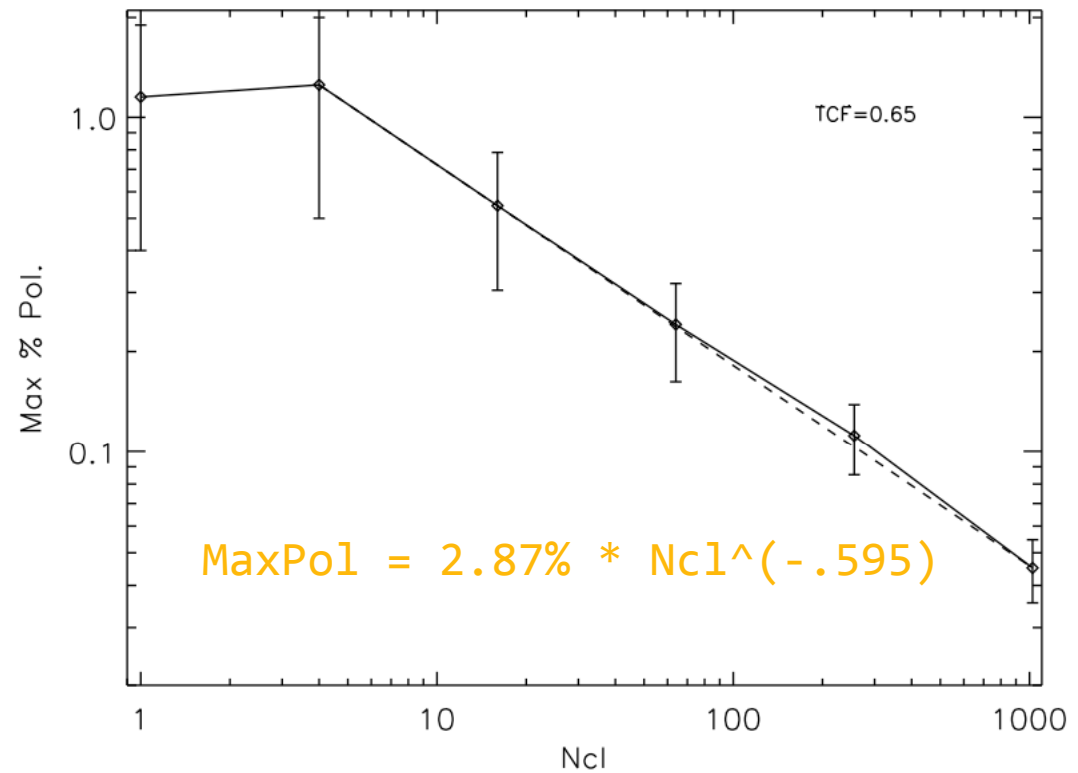
- ejecta asphericity (electron scattering)
- occultation by clump or CSM
- scattering in CSM
- non-homologous expansion
- all of the above



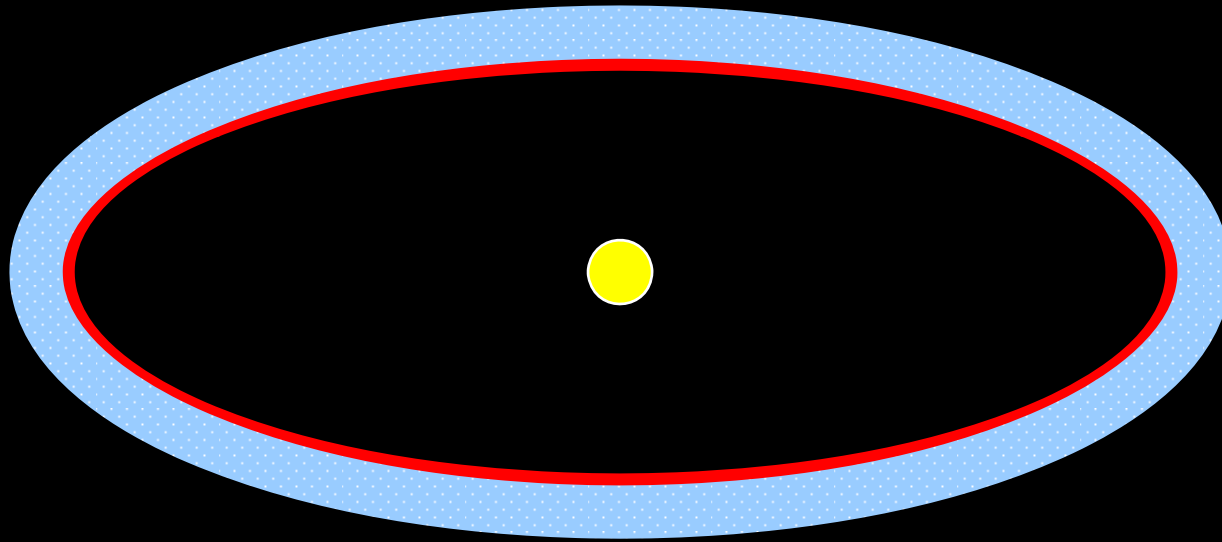


Hole poster

Clumpy ejecta models derive statistical line polarization results from large ensembles.



Scattering models investigate emission line polarization profiles.



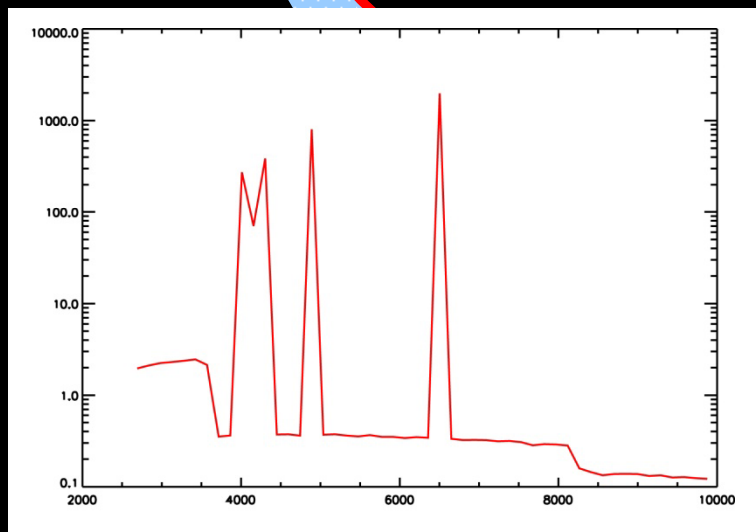
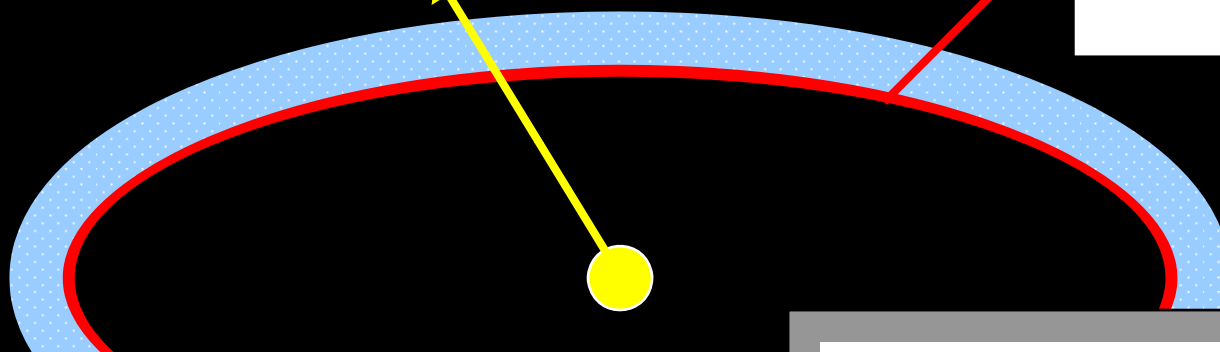
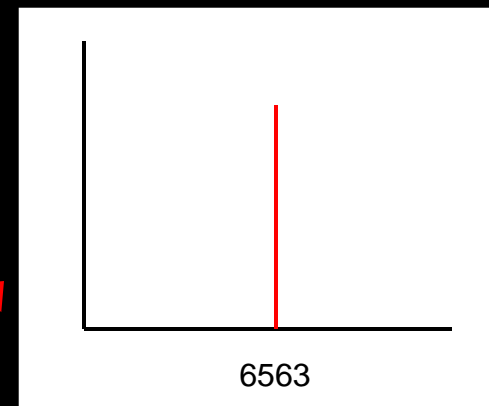
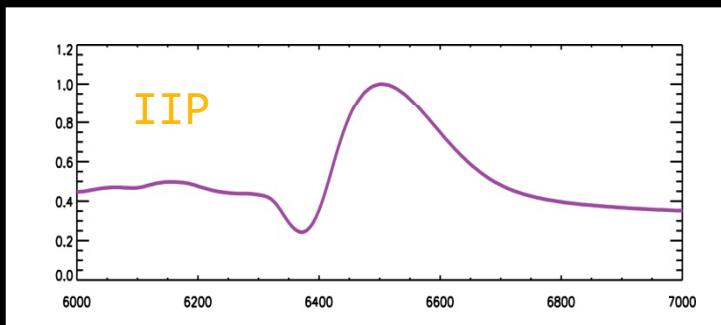
Overview

Observations

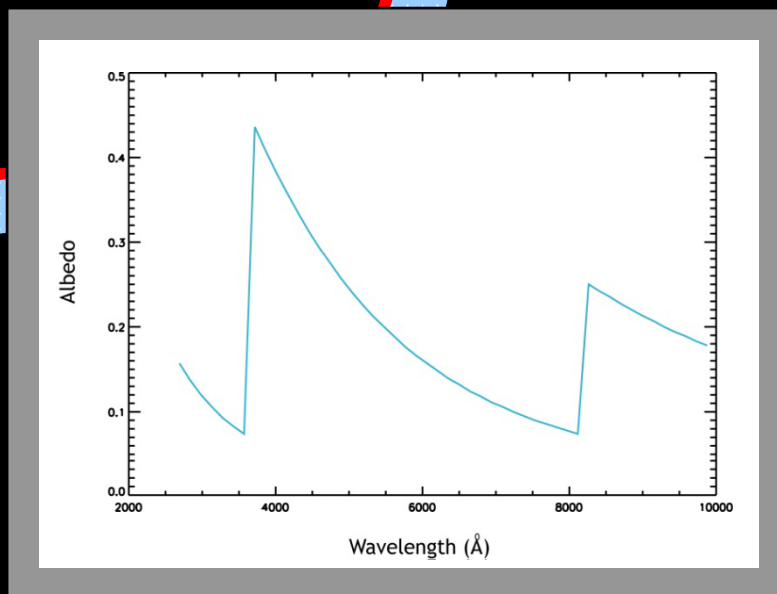
Modeling

Future

Announcements

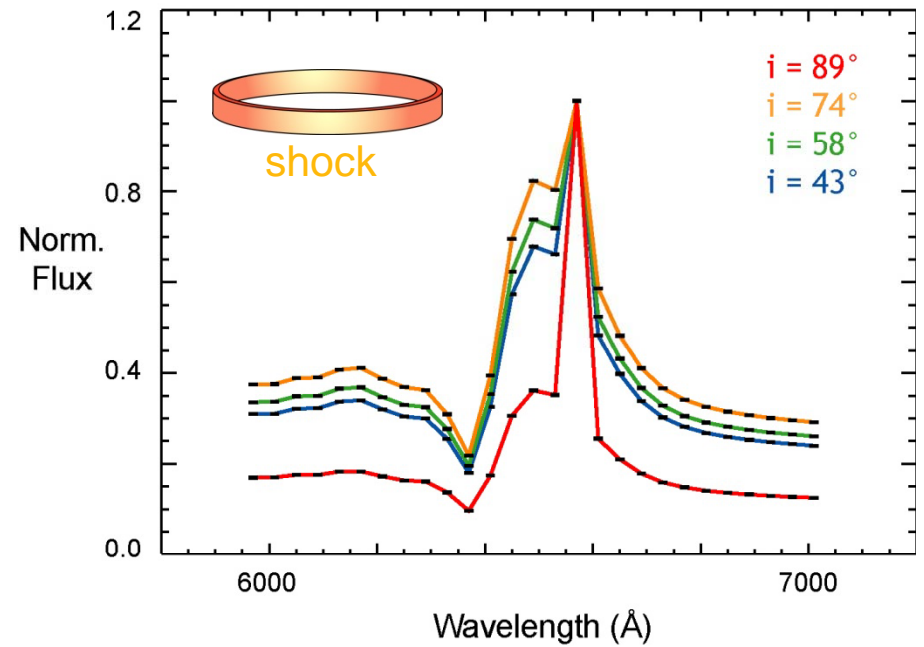
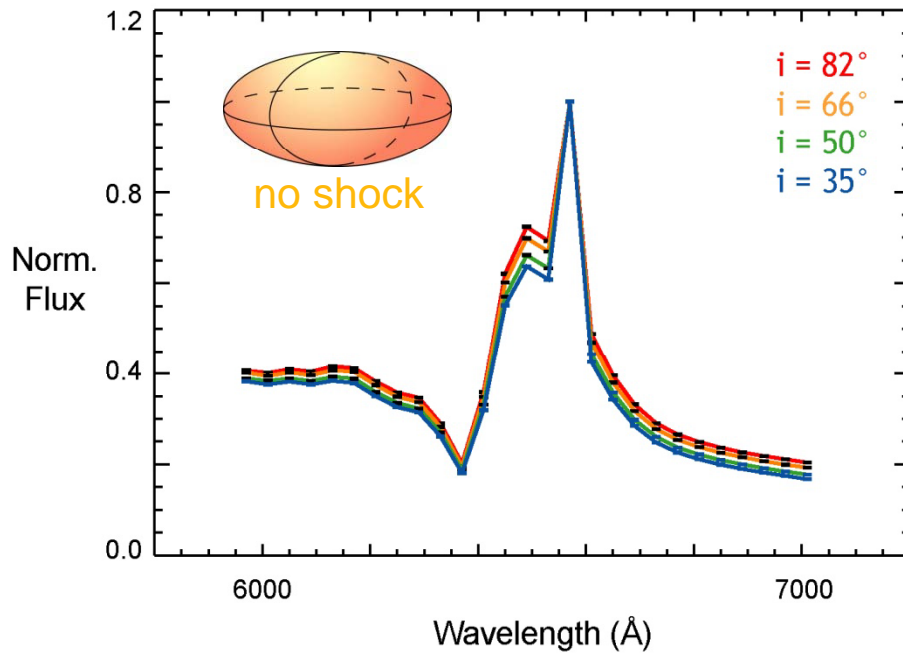
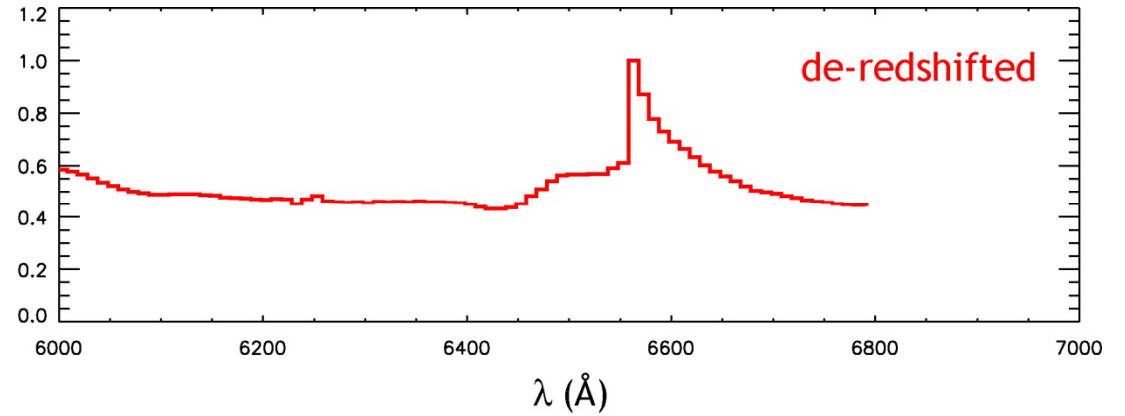


T, τ , L,
geom.



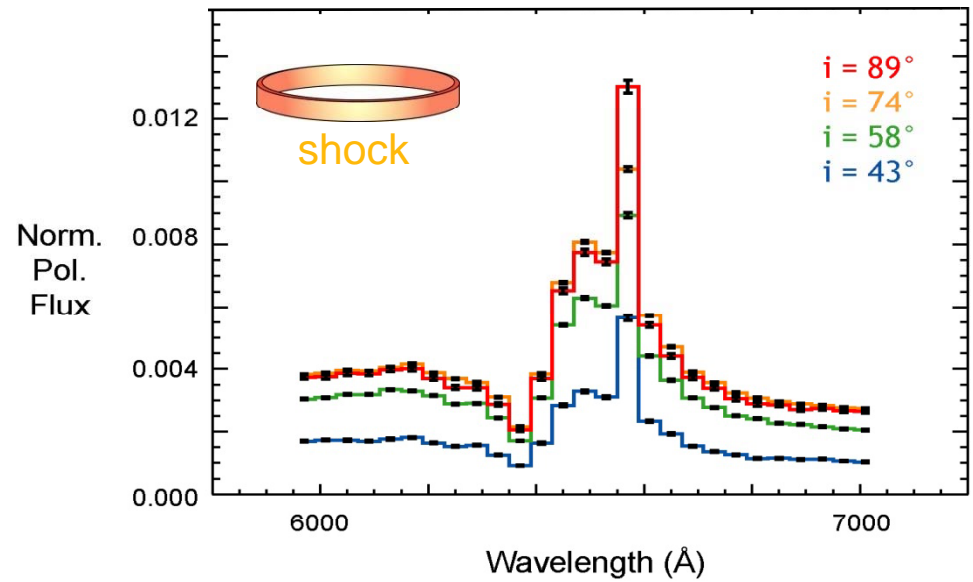
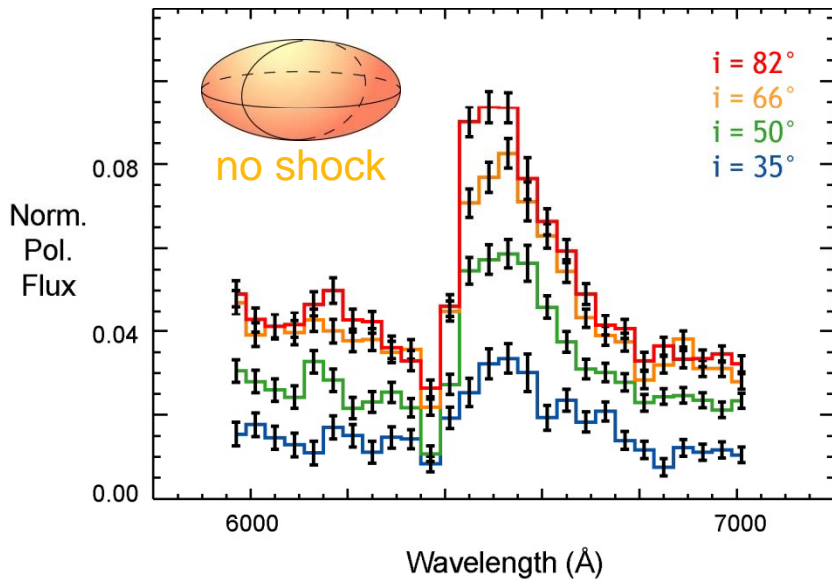
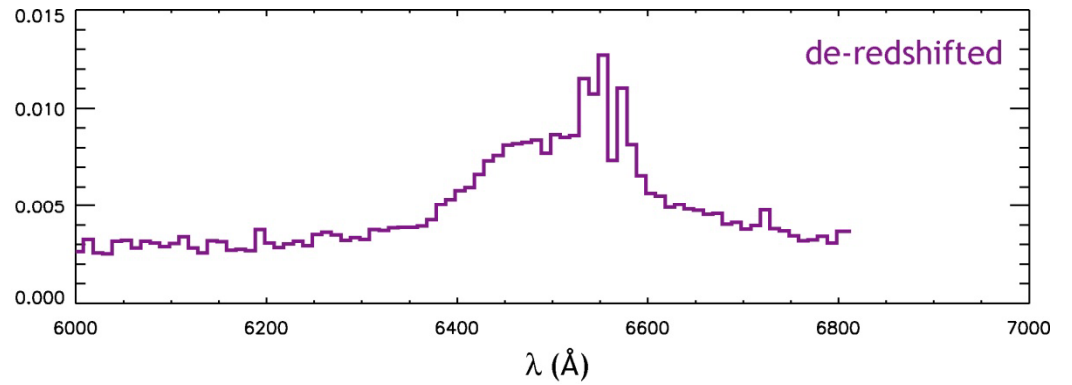
SN 2000P
13 d post-discovery

Normalized
Flux



SN 1997eg
44 d post-discovery

Normalized
Polarized Flux



Where are we now?

- We've realized the importance of polarimetry (especially time-dependent).
- Detailed spectropolarimetry is yielding insight into asymmetries of explosions, ejecta composition, and CSM.
- Modeling is catching up with observations.



SN 2002bo, Benetti et al. 2004

What's next?

- More detailed models
- Better statistics: more SNe, greater wavelength and time coverage
- Classification: can polarimetry help disentangle categories?
(Viewing angle degeneracy)
- Late stellar evolution: can polarimetry help identify, study SN progenitors?



SN 2004dj

Overview

Observations

Modeling

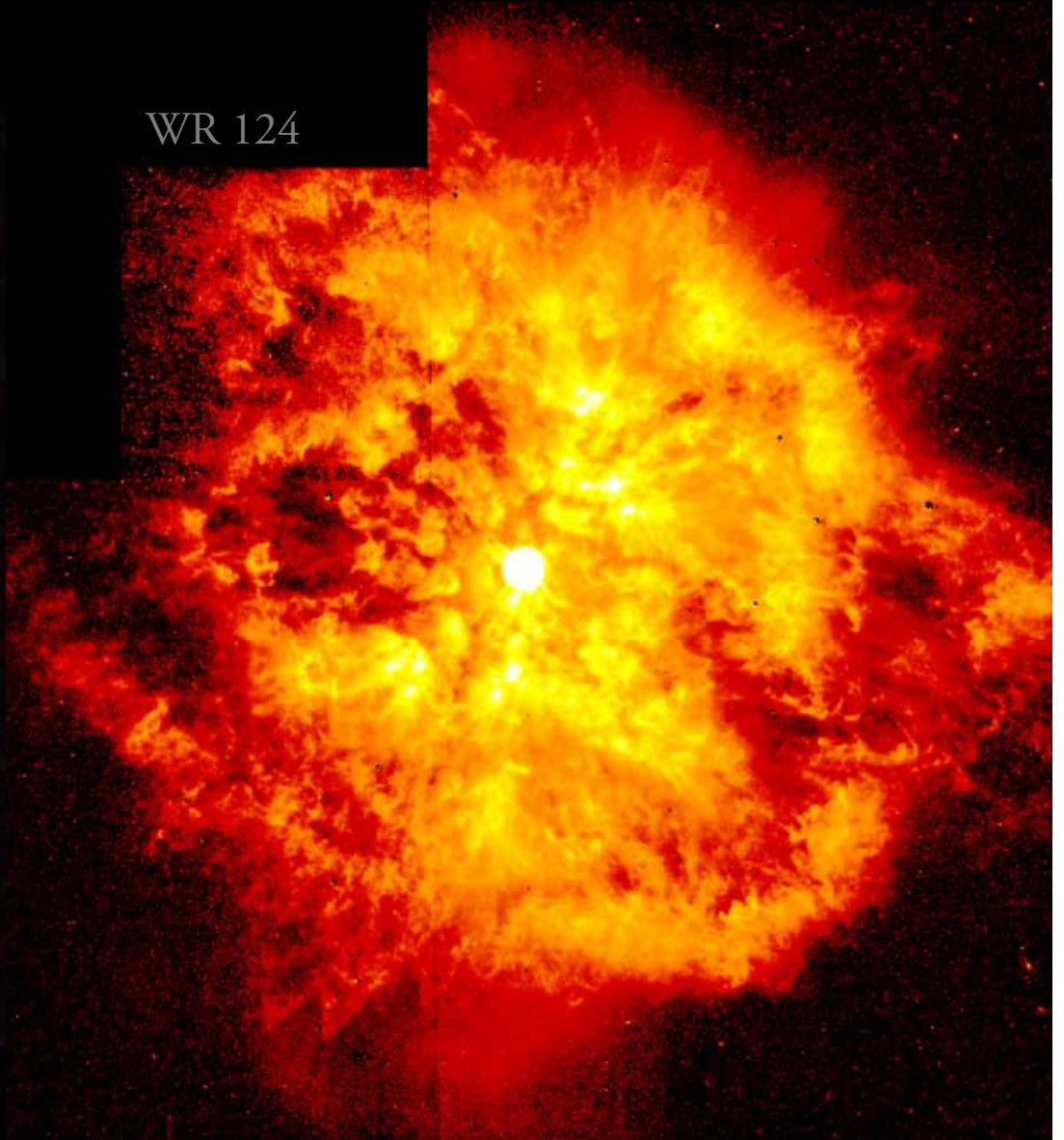
Future

Announcements



SN 1987A

WR 124



HPOL moving to Mt. Lemmon (2009)

Low-res but dedicated optical spectropolarimeter, good for time coverage of bright objects, will be available to community.

→ K. Bjorkman (Toledo), J. Hoffman (DU), T. Jones (Minnesota)

ϵ Aur needs polarimetrists

Unusual eclipsing binary will enter a 2-year eclipse in August 2009.

Polarimetry can help constrain properties of tilted disk. See newsletter.

→ R. Stencel (DU)

Postdoctoral position: massive stars/SNe/polarimetry/modeling

NSF has funded a 5-year project to study the relation between CSM of supernovae and massive stellar winds. Spectropolarimetry and RT modeling will be important tools. PI status!

→ R. Ignace (ETSU), J. Hoffman (DU)